Module 4.

Hydrology

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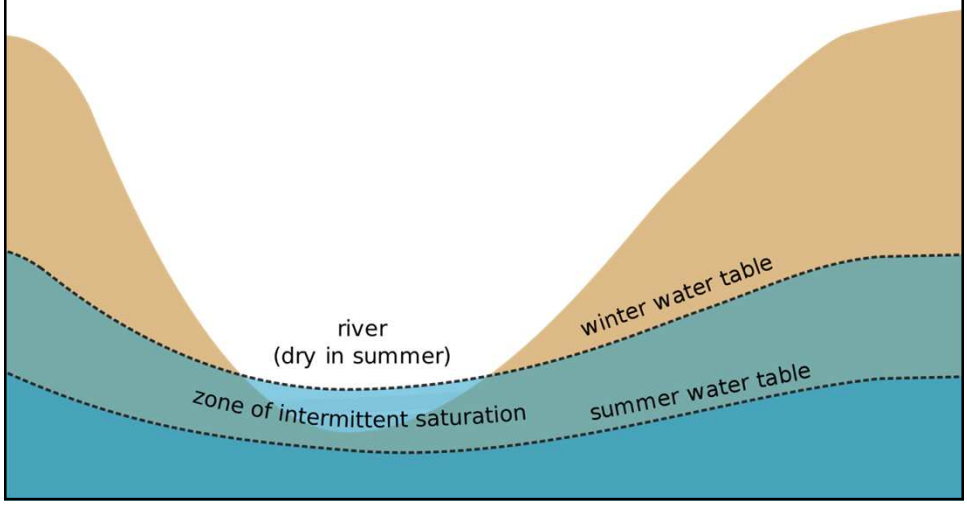
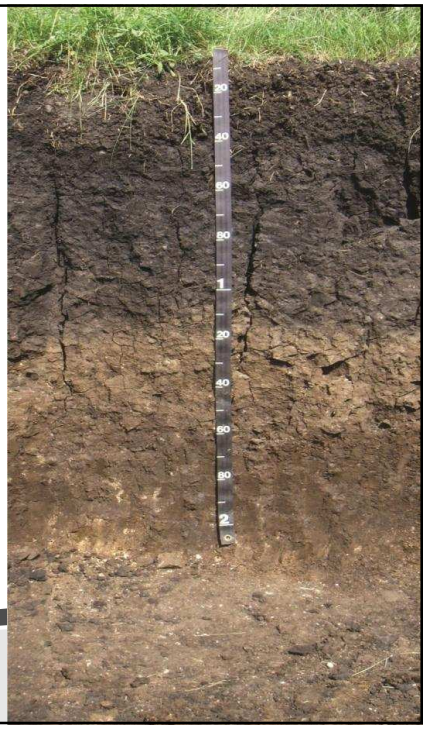
Subsurface Hydrology



Soil Limitations on BMP Placement

1. Depth
   A minimum of 2-4 ft below the bottom of the practice
2. Infiltration/Permeability
   At least 0.5 in/hr, design ½ of measured



What's wrong with a high water table?

1. Reduces the effective soil depth for treatment of an infiltration practice
2. Reduces the hydraulic gradient to drain the practice
3. Reduces the effective volume of a ponding practice

How high is the SHWT relative to the final bottom elevation of the practice?

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Resources for Evaluating Site Subsurface Hydrology

- Soil Survey (hydrologic soil groups, hydric soils)
- USGS Map
- Geotechnical Report
- Satellite Photos
- Wetlands Inventory Map
- Wetlands Delineation
- Site Plan

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2014

2012

2011

2008

2002

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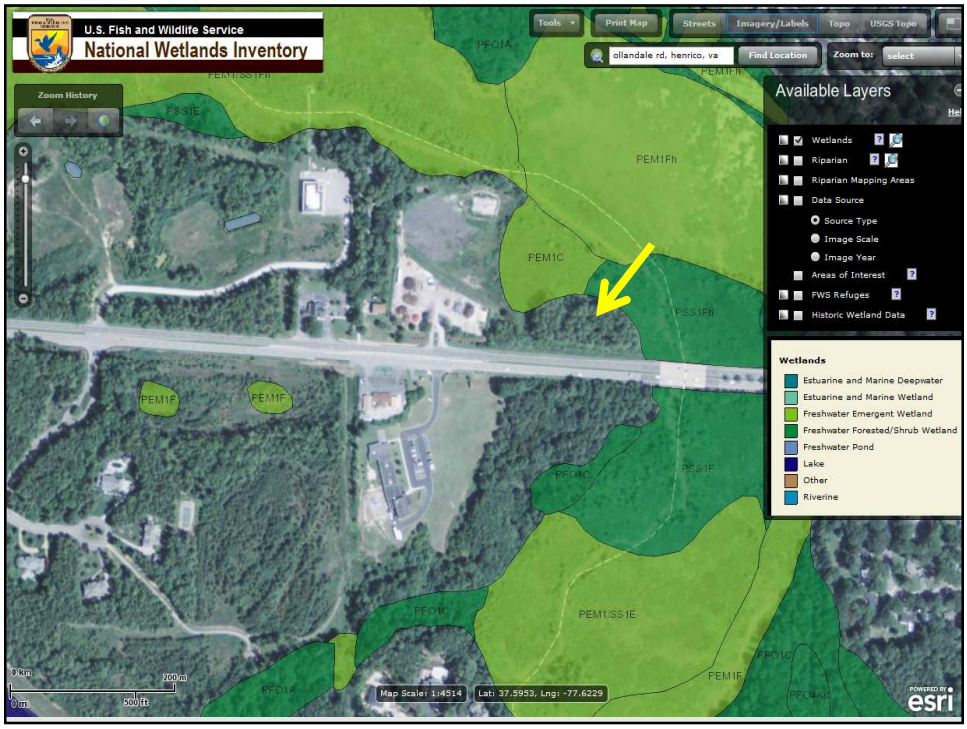

8B—Creedmoor fine sandy loam, 2 to 7 percent slopes

Map Unit Setting

National map unit symbol: 3zwq
Elevation: 300 to 450 feet
Mean annual precipitation: 35 to 48 inches
Mean annual air temperature: 76 to 100 degrees F
Frost-free period: 153 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Creedmoor and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Creedmoor

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Triassic residuum

Typical profile

H1 - 0 to 6 inches: fine sandy loam
H2 - 6 to 9 inches: sandy clay loam
H3 - 9 to 42 inches: clay
H4 - 42 to 66 inches: sandy loam

Properties and qualities

Slope: 2 to 7 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.9 inches)

Wetland delineation confirms water table rises to within 1 ft of the surface

SO: if the proposed BMP is adjacent to a wetland, the water table will likely be too high for most infiltration practices

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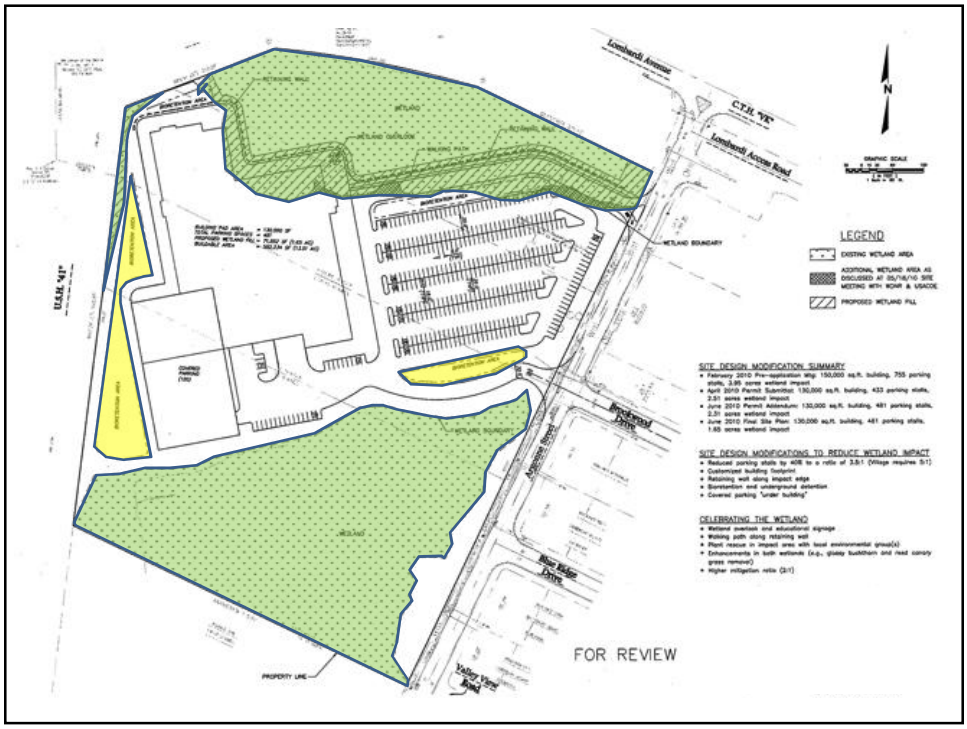
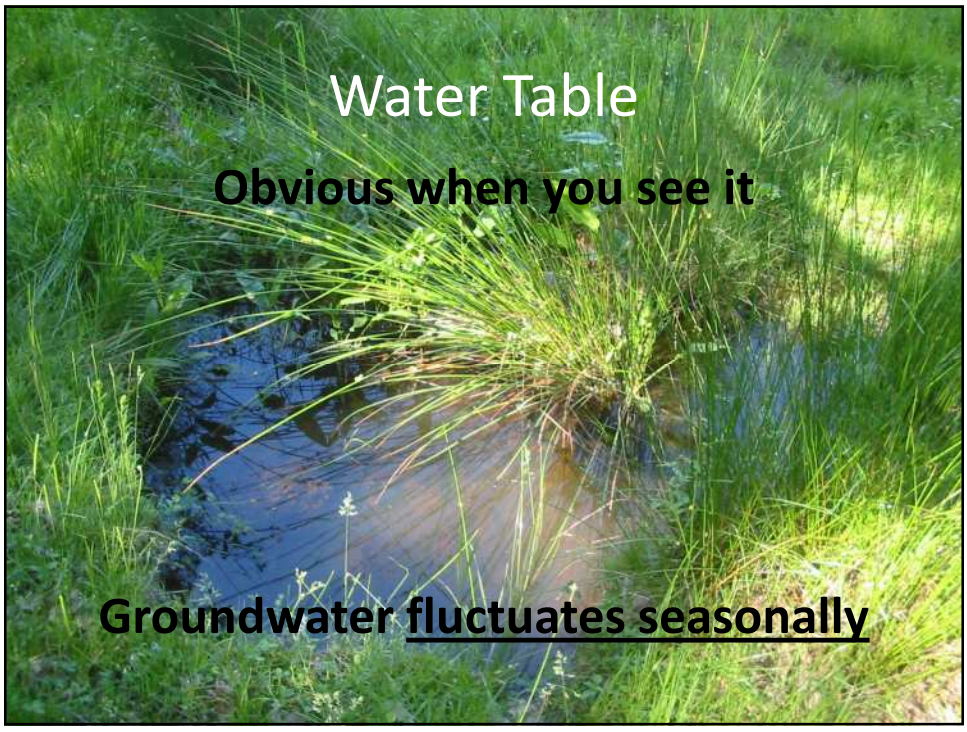
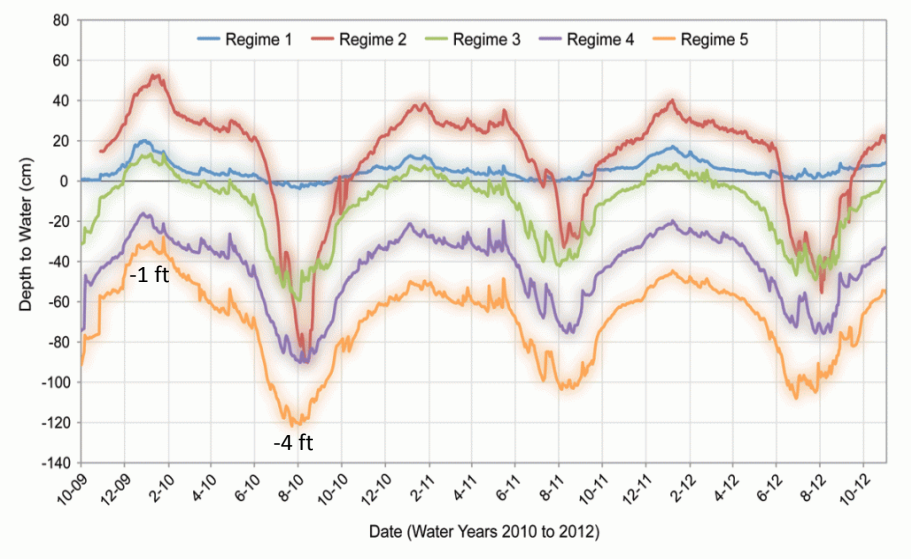


Can roughly estimate depth to water table on a site from the elevation of surface water



Seasonal High Water Table



Seasonal High Water Table

Soils can have a visual record of saturation when:

1. Organic matter is present
2. Bacteria are active
3. Iron (Fe) is present

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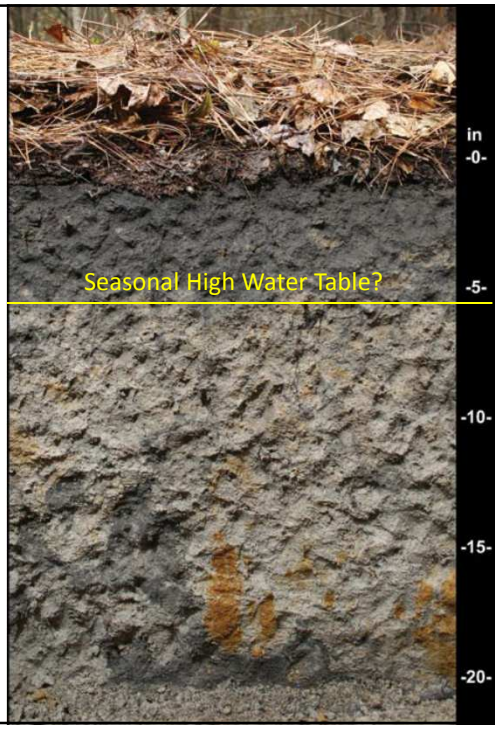
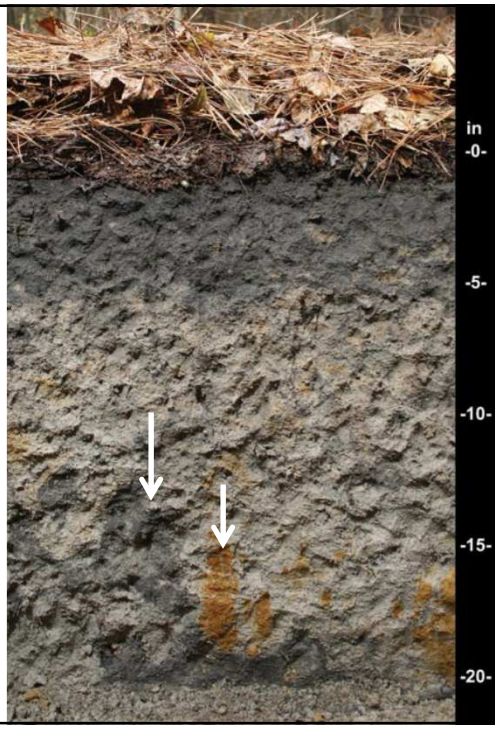
Iron (Fe) & manganese (Mn) oxides give soil brown, red & yellow colors

Under reducing conditions (saturation), they dissolve and move down with the water, leaving the depleted soil (matrix) grey



As the water recedes, the air entering the soil re-oxidizes the Fe&Mn oxides, forming colorful pore/crack linings, root channel linings, masses, nodules, and concretions lower in the soil profile



DEQ 2013 STORMWATER DESIGN SPECIFICATION No. 8

The SHWT may be determined using soil morphology throughout the year by a certified professional registered in Virginia, with training and experience in soil morphology (certified professional soil scientist, professional wetland delineator or professional geologist). Professional engineers registered in Virginia with experience in the field of geotechnical engineering may also be certified to determine the SHWT provided that they have successfully completed training on soil morphology deemed to be acceptable to the VSMP Authority.

Understanding Soil Morphology

Seasonal High Water Table

Signs of reduction (depletion)

Signs of oxidation (concentrations)

Signs of translocation (movement in profile)

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Interpreting soil morphology

- Redox features can be difficult to decipher
- Redox-like features can occur in unsaturated soils
- Redox-like features may be parent material
- Redox features may be masked by parent material
- Redox features may be relic or contemporary
- Redox features may be inhibited from forming due to low organic carbon, high pH, cold temperatures, or aerated groundwater

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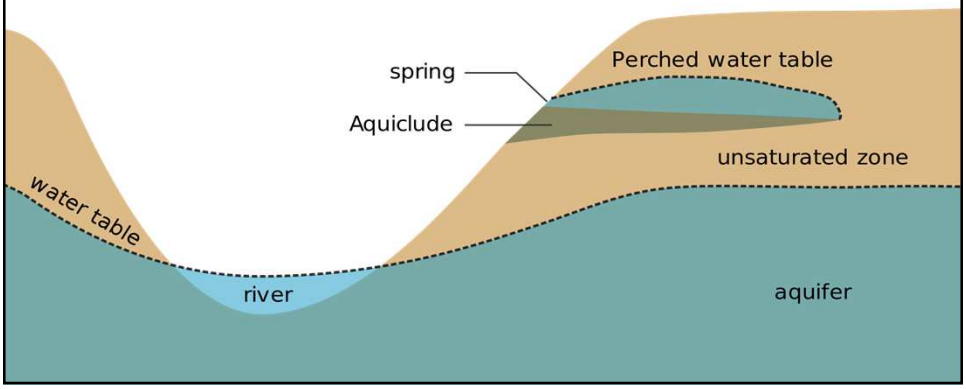
Seasonal High Water Table

Water can accumulate or "perch" on top of a restrictive layer – perched water table



Infiltration & Percolation

Infiltration Practices

- Rooftop disconnect
- Vegetated Filter Strip
- Grass Channels
- Permeable Pavement
- Infiltration Trench/Basin
- Bioretention
- Dry Swales

Test Pit/Boring Procedures

2013 Appendix 8-A (SW Design Spec. No. 8)

- Located at BMP area
- To a depth at least 4ft below bottom of BMP
- Describe all soil horizons (USDA or Unified)
- Identify the most hydraulically restrictive layer to determine infiltration
- Identify height of seasonal high water table (redoximorphic features)

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Test Pit/Boring Procedures

Area of Practice	# of Soil Profile Explorations	# of Infiltration (Permeability) Tests
Up to 2,500 ft^2	1	2
2,500 ft2 to 5,000 ft^2	2	3
5,000 ft2 to 7,500 ft^2	2	4
7,500 ft2 to 10,000 ft^2	2	5
Greater than 10,000 ft^2	Add 1 soil profile and 2 infiltration tests for each additional 5,000 ft^2 of practice	

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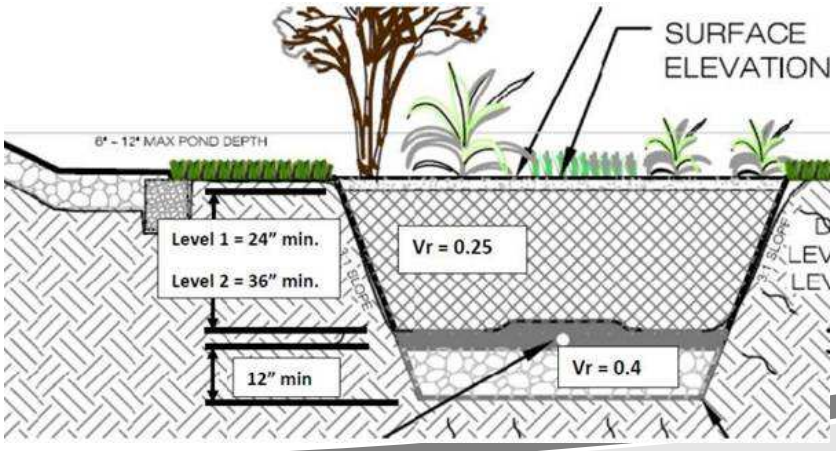
Test Pit/Boring Procedures

2013 Appendix 8-A (SW Design Spec. No. 8)

Permeability tests must be conducted at the most restrictive layer between the bottom elevation of the proposed infiltration BMP and a depth of 4 feet below the bottom, or two times the maximum potential water depth in the BMP, whichever is greater.

Water Depth



Samples of Tests		SPT			
Type	Depth, m	N	Depth	Legend	Strata Description
D	0.30		0.20		Tarmac over hardcore
B	0.50				Made ground (clay with brick rubble)
B	1.00-1.50	10	0.90		Brown clay with flints
D	1.75				
B	2.00-2.50	19			
			2.30		Brown-grey sand with some clay binder
D	2.75				
D	3.00-3.50	24			
D	4.00				
D	4.50-5.00	35	4.50		Brown sandy clay with flints
D	5.50				
D	6.00-6.50	17			

Where is the most restrictive layer?

Boring Log

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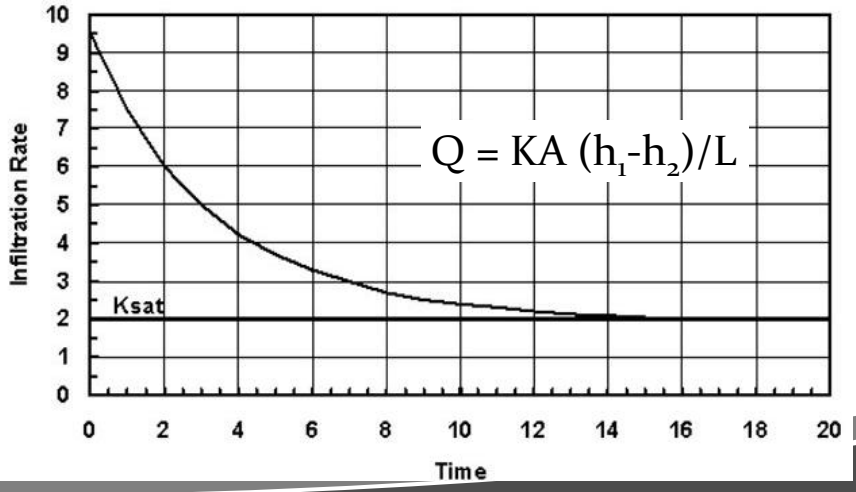
Saturated Hydraulic Conductivity

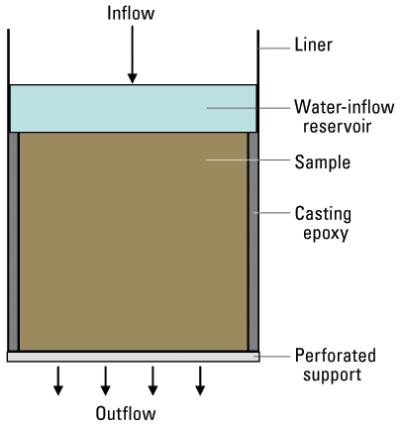


Determination of K_{sat}

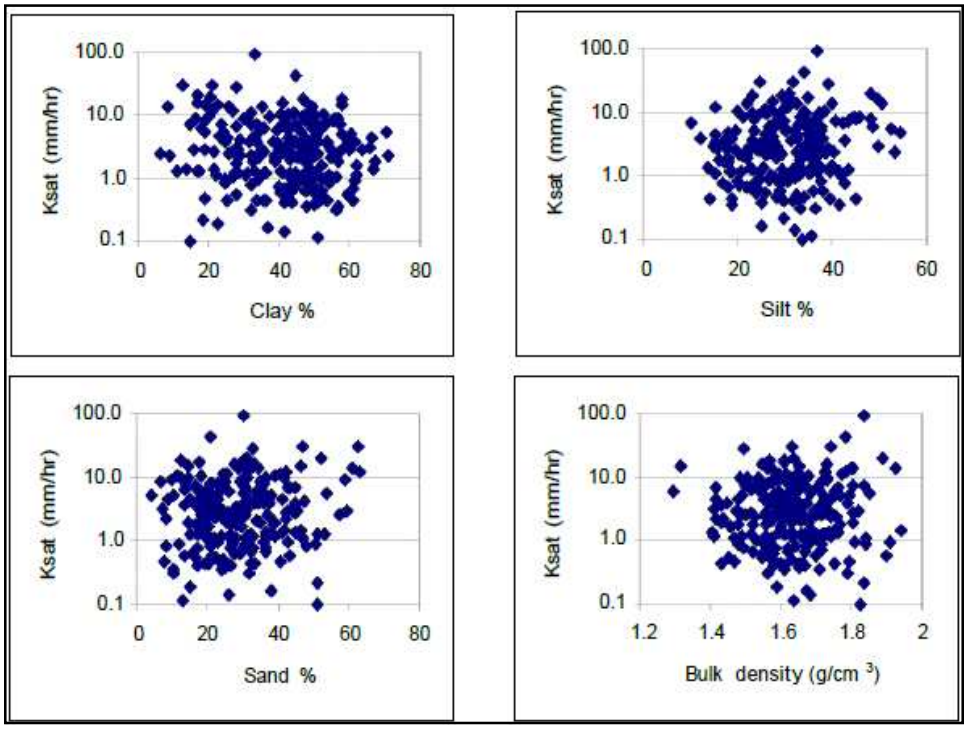
1. Field Methods
2. Laboratory Methods
3. Empirical Methods

Determination of Ksat

Determination of Ksat



$$Q = KA\ (h_1\text{-}h_2)/L$$

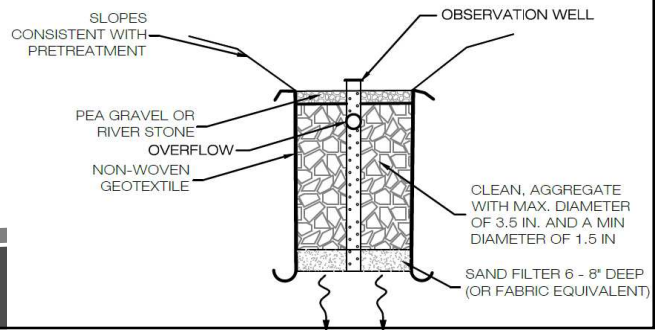


Restrictions to Infiltration

- Low infiltration rates
- Shallow soils
- Seasonal high water table
- Groundwater protection
  - Pollution Hotspots
  - Karst Topography

Infiltration Design

- Pretreatment to remove fines
- Ponding for water quality volume
- Stone sump for water quality volume
- Overflow or Bypass



Practices with subsurface infiltration

- Rooftop disconnect with micro-practice
- Permeable pavement Level 2
- Infiltration practices (trench – basin)
- Bioretention Level 2
- Dry swale Level 2

Required Permeability Rates

- ½ in/hr for level 1 design
- 1 in/hr for level 2 design
- ½ - 1 in/hr required to avoid underdrains, depending on the practice

Infiltration Requirements

Design Factor	Micro-Infiltration	Small-Scale Infiltration	Conventional Infiltration
Impervious Area Treated	250 to 2,500 sq. ft.	2,500 to 20,000 sq. ft.	20,000 to 100,000 sq. ft.
Typical Practices	Dry Well French Drain Paving Blocks	Infiltration Trench Permeable Paving [1]	Infiltration Trench
Min. Infiltration Rate	1/2 inch/hour field verified		
Design Infil. Rate	50% of measured rate		
Observation Well	No	Yes	Yes
Type of Pre-treatment (see **Table 8.6**)	External (leaf screens, grass filter strip, etc)	Vegetated filter strip or grass channel, forebay, etc.	Pre-treatment Cell
Depth Dimensions	Max. 3-foot depth	Max. 5-foot depth	Max. 6-foot depth,
UIC Permit Needed	No	No	Ff the surface width is less than the max. depth
Head Required	Nominal: 1 to 3 feet	Moderate: 1 to 5 feet	Moderate: 2 to 6 feet
Building Setbacks	10 feet down-gradient [2]	10 feet down-gradient 50 feet up-gradient	25 feet down-gradient 100 feet up-gradient

Practices with surface infiltration

- Simple rooftop disconnect
- Sheetflow to conservation area
- Sheetflow to vegetated filter strip
- Grass channel

Requirements for surface infiltration

- Limited drainage area
- Hydrologic soil group (compost amendment)
- Slope vs. width & length
- Flow control

Flow control

- Gravel diaphragm for sheet flow
- Level spreader for concentrated flow
- Down-gradient stability
- High flow bypass

Maximize Surface Infiltration

Good soils
- HSG A or B

Modified soil
- Ripping subsoil/pans
- Compost surface incorporation
- Soil Media Mix

Limit contributing drainage area

Just like a tub, a BMP's gotta drain between baths!